

Characterizing Blast Exposure and mild TBI in OEF/OIF Veterans using the Boston Assessment of TBI-Lifetime

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The Boston Assessment of Traumatic Brain Injury-Lifetime (BAT-L) Semi-structured Interview: Preliminary Evidence of Research Utility and Validity

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The Boston Assessment of Traumatic Brain Injury–Lifetime (BAT-L) Semistructured Interview: Evidence of Research Utility and Validity

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Objective: Report the prevalence of lifetime and military-related traumatic brain injuries (TBIs) in Operation Enduring Freedom and Operation Iraqi Freedom (OEF/OIF) veterans and validate the Boston Assessment of TBI–Lifetime (BAT-L). **Setting:** The BAT-L is the first validated, postcombat, semistructured clinical interview to characterize head injuries and diagnose TBIs throughout the life span. **Participants:** Community-dwelling convenience sample of 131 OEF/OIF veterans. **Design:** TBI criteria (alteration of mental status, posttraumatic amnesia, and loss of consciousness) were evaluated for all possible TBIs, including a novel evaluation of blast exposure. **Main Measures:** BAT-L, Ohio State University TBI Identification Method (OSU-TBI-ID). **Results:** About 67% of veterans incurred a TBI in their lifetime. Almost 35% of veterans experienced at least 1 military-related TBI; all were mild in severity, 40% of them were due to blast, 50% were due to some other (ie, blunt) mechanism, and 10% were due to both types of injuries. Predeployment TBIs were frequent (45% of veterans). There was strong correspondence between the BAT-L and the OSU-TBI-ID (Cohen $\kappa = 0.89$; Kendall $\tau\text{-b} = 0.95$). Interrater reliability of the BAT-L was strong ($\kappa\text{s} > 0.80$). **Conclusions:** The BAT-L is a valid instrument with which to assess TBI across a service member's lifetime and captures the varied and complex nature of brain injuries across OEF/OIF veterans' life span. **Key words:** assessment, blast, OEF/OIF, traumatic brain injury (TBI), veterans

MILD TRAUMATIC BRAIN INJURY (mTBI) is the so-called signature injury of Operation

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To download the full BAT-L semi-structured clinical interview go to: <http://www.headtraumabab.com/>.

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Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF), yet its identification and diagnosis are controversial and fraught with challenges. Diagnosis of military-related mTBI in OEF/OIF veterans is complex and unique from the diagnosis of civilian-acquired brain injuries in a number of ways. This is due to the novel mechanism of injury (exposure to blast(s) such as an improvised explosive device), the frequent co-occurrence of head injury and psychological trauma during the chaos of combat that make the determination of altered mental status (AMS) difficult, and the difficulty obtaining in-theater documentation of symptoms at the time of injury for determining the presence or absence of mTBI. Although in-theater documentation of injuries is improving in more recent years, for the majority of OEF/OIF veterans, injuries were

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mTBI

- Mild Traumatic Brain Injury (mTBI) is the “signature injury” of OEF/OIF
- Estimates suggest between 9-23 percent of OEF/OIF veterans suffer at least one mTBI during service

Assessment of mTBI

Diagnosis of military mTBI is complex and unique from the diagnosis of civilian acquired brain injury

1. novel mechanism of injury (exposure to blast(s) such as IED)
2. co-occurrence of head injury and psychological trauma during combat
3. difficulty obtaining in-theater documentation of symptoms at the time of injury

Principle Cause of Combat-Related TBI

- Improvised Explosive Devices (IEDs)



Secondary blast-induced neurotrauma
(penetrating head injury)



Primary blast-induced neurotrauma
(without a direct blow to the head)



- kinetic energy transfer to the CNS
- lung injury- induced hypoxia/ischemia
- hemorrhage-induced hypoxia/ischemia
- hormones released from injured tissue

Tertiary blast mechanisms
(i.e. effect of the impacts
with other objects)



Site of impact
"coup"



Injury to the brain
opposite the site
of impact
"contrecoup"

Secondary blast mechanisms
(i.e. effect of the missiles
being propelled by
blast force)

Primary blast mechanisms
(i.e. effects of the blast wave itself)

Tertiary blast-induced neurotrauma
(coup-contrecoup)

Assessment of mTBI

Limitations of existing measures:

1. Developed for civilian population
2. Military measures focus on combat injuries only
3. Designed to detect military TBI (not severity or duration of symptoms)
4. Frequent co-occurrence of TBI and stress/trauma necessitate a more refined assessment of head injury than previously required



BOSTON ASSESSMENT OF TBI – LIFETIME

BAT-L



Have you ever experienced a blow to the head?

Listed below are situations in which you may have experienced a blow to the head. For each event listed, please circle yes or no to indicate if you have experienced it. If yes, did you lose consciousness and/or were you dazed or confused as a result?

| # | Did you experience this event | | If you experienced the event... | | | | | |
|----|--|-----------|---------------------------------|----|--------|------------------------------|----|--------|
| | | | Did you lose consciousness? | | | Were you dazed and confused? | | |
| 1 | In a car crash? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 2 | In a motorcycle crash? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 3 | In an all-terrain vehicle crash? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 4 | As a pedestrian hit by a vehicle? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 5 | Being hit by a falling object? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 6 | Being hit by equipment? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 7 | Falling down stairs? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 8 | Falling from a high place? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 9 | During a fainting spell? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 10 | During a drug or alcohol blackout? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 11 | While biking? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 12 | While roller blading/roller boarding? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 13 | While horseback riding? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 14 | While skiing? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 15 | While sky diving? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 16 | While participating in other sports? ex: football, hockey, baseball, basketball, soccer, lacrosse, boxing, wrestling, martial arts, etc. | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 17 | While on the playground? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 18 | While diving into water? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 19 | Being physically abused? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 20 | While being assaulted or mugged? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 21 | During a military or other training exercise? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 22 | During combat? | Yes No | Yes | No | Unsure | Yes | No | Unsure |
| 23 | Other? | Yes No | Yes | No | Unsure | Yes | No | Unsure |

BAT-L SUMMARY SCORE SHEET

MILITARY-RELATED BLAST:

| Total # of Blast Exposures: | 0 - 10 Meters | 11 - 25 Meters | 26 - 100 Meters |
|-----------------------------|----------------------|----------------------|----------------------|
| <input type="text"/> | <input type="text"/> | <input type="text"/> | <input type="text"/> |

| | |
|---------------------|----------------------|
| Total # Blast TBIs: | <input type="text"/> |
|---------------------|----------------------|

| 1 st Most Severe | | 2 nd Most Severe | | 3 rd Most Severe | |
|-----------------------------|--|-----------------------------|--|-----------------------------|--|
| Age | <input type="text"/> | Age | <input type="text"/> | Age | <input type="text"/> |
| AMS | <input type="text"/> hr / min / sec | AMS | <input type="text"/> hr / min / sec | AMS | <input type="text"/> hr / min / sec |
| PTA | <input type="text"/> hr / min / sec | PTA | <input type="text"/> hr / min / sec | PTA | <input type="text"/> hr / min / sec |
| LOC | <input type="text"/> hr / min / sec | LOC | <input type="text"/> hr / min / sec | LOC | <input type="text"/> hr / min / sec |
| Severity | If Mild: <input type="checkbox"/> Mild <input type="checkbox"/> Stage I <input type="checkbox"/> Moderate <input type="checkbox"/> Stage II <input type="checkbox"/> Severe <input type="checkbox"/> Stage III | Severity | If Mild: <input type="checkbox"/> Mild <input type="checkbox"/> Stage I <input type="checkbox"/> Moderate <input type="checkbox"/> Stage II <input type="checkbox"/> Severe <input type="checkbox"/> Stage III | Severity | If Mild: <input type="checkbox"/> Mild <input type="checkbox"/> Stage I <input type="checkbox"/> Moderate <input type="checkbox"/> Stage II <input type="checkbox"/> Severe <input type="checkbox"/> Stage III |
| BATL Score (0 – 5) | <input type="text"/> | BATL Score (0 – 5) | <input type="text"/> | BATL Score (0 – 5) | <input type="text"/> |
| Nature of Blast | <input type="checkbox"/> Primary (Head) <input type="checkbox"/> Secondary (Head: <input type="checkbox"/> Yes <input type="checkbox"/> No) <input type="checkbox"/> Tertiary (Head: <input type="checkbox"/> Yes <input type="checkbox"/> No) <input type="checkbox"/> Quaternary (Head: <input type="checkbox"/> Yes <input type="checkbox"/> No) | Nature of Blast | <input type="checkbox"/> Primary (Head) <input type="checkbox"/> Secondary (Head: <input type="checkbox"/> Yes <input type="checkbox"/> No) <input type="checkbox"/> Tertiary (Head: <input type="checkbox"/> Yes <input type="checkbox"/> No) <input type="checkbox"/> Quaternary (Head: <input type="checkbox"/> Yes <input type="checkbox"/> No) | Nature of Blast | <input type="checkbox"/> Primary (Head) <input type="checkbox"/> Secondary (Head: <input type="checkbox"/> Yes <input type="checkbox"/> No) <input type="checkbox"/> Tertiary (Head: <input type="checkbox"/> Yes <input type="checkbox"/> No) <input type="checkbox"/> Quaternary (Head: <input type="checkbox"/> Yes <input type="checkbox"/> No) |

BAT-L Assessment Approach

- TBI is assessed during 3 time epochs:
 - (1) Pre-Military
 - (2) Military
 - (3) Post-Military
- Evaluate 3 most severe injuries in each epoch
- Open-ended questioning & “Forensic Approach”
- Factors related to estimation of AMS queried
- Occurrence and duration of neurobehavioral symptoms following each injury recorded

TBI Severity is Rated According to DOD Criteria

| Criteria | Mild | Moderate | Severe |
|-----------------------------|----------------|---|------------|
| Loss of Consciousness | 0 - 30 minutes | >30 minutes and <24 hours | > 24 hours |
| Alteration of Mental Status | 0 - 24 hours | >24 hours; severity based on other criteria | |
| Post Traumatic Amnesia | 0 - 1 day | > 1 day and <7 days | > 7 days |
| Glasgow Coma Scale | 13 - 15 | 9 - 12 | <9 |

DOD, 2009

Mild TBI Graded with Hybrid Classification

| Criteria (must be > 0 for one of the following criteria) | Grade I | Grade II | Grade III |
|--|----------------|---------------------------|-------------|
| Loss of Consciousness | None | < 5 minutes | > 5 minutes |
| Post Traumatic Amnesia | 0 - 15 minutes | <24 hours but >15 minutes | >24 hours |
| Alteration of Mental Status | 0 - 15 minutes | <24 hours but >15 minutes | >24 hours |

Developed from Bailes & Cantu, 2001

Demographics/Deployment Information

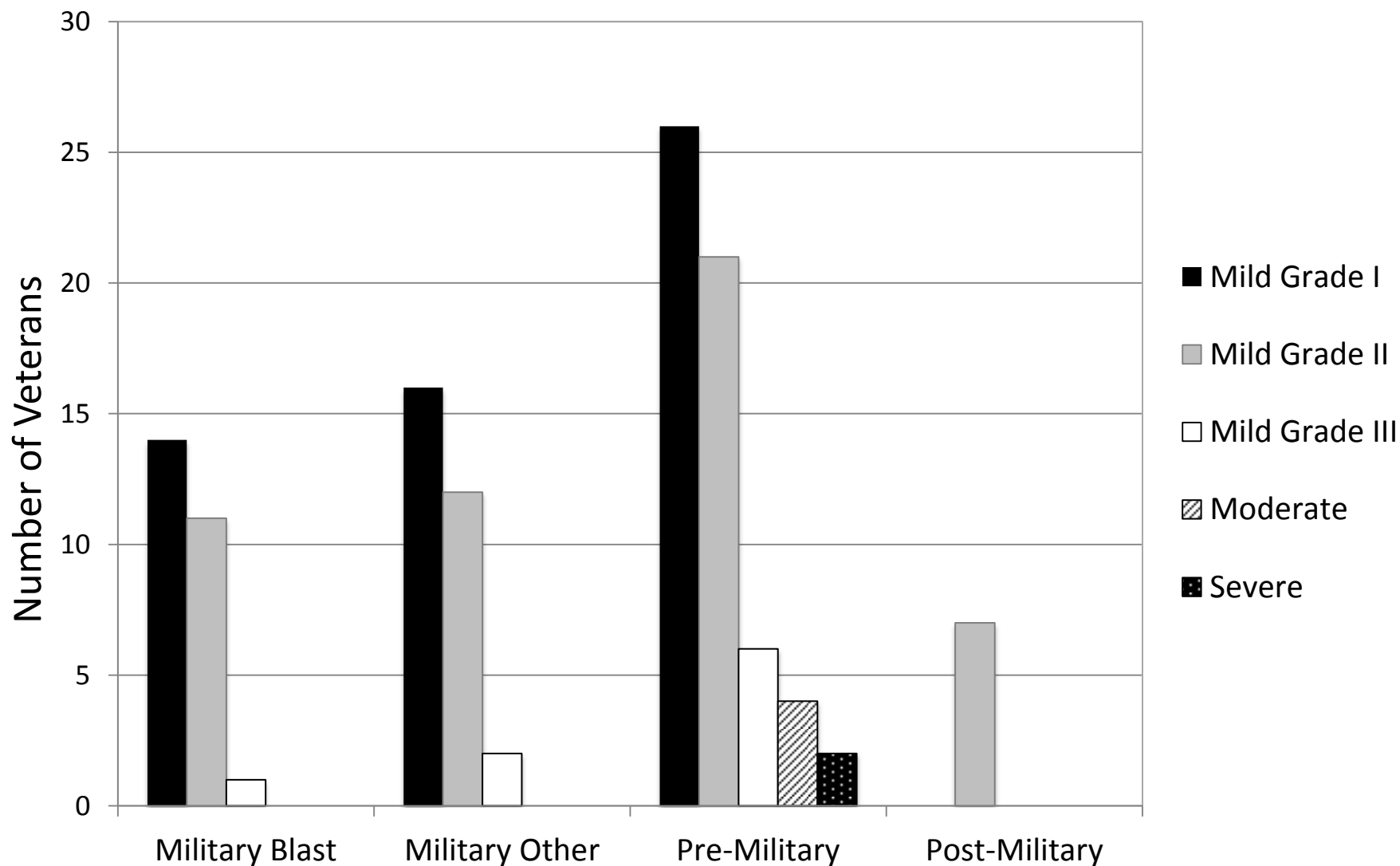
BAT-L Validation from TRACTS Cohort (n=131)

| | |
|-------------------------------------|---|
| | |
| Gender | 85% male 15% female |
| Age | 33.9 years (9.22) Range: 20-62 |
| Ethnicity | White/Caucasian 74.8% Hispanic/Latino 11.5% American Indian 1.5% Asian 2.3% Black/African American 8.4% |
| Years of Education | 13.7 (1.80) Range: 12-20 |
| Number of Deployments | 1.26 (0.48) Range: 1-3 |
| Duration of Deployments (months) | 13.4 (7.18) Range: 3 - 38 |
| Time since last Deployment (months) | 33.8 (24.3) Range: 1-99 |

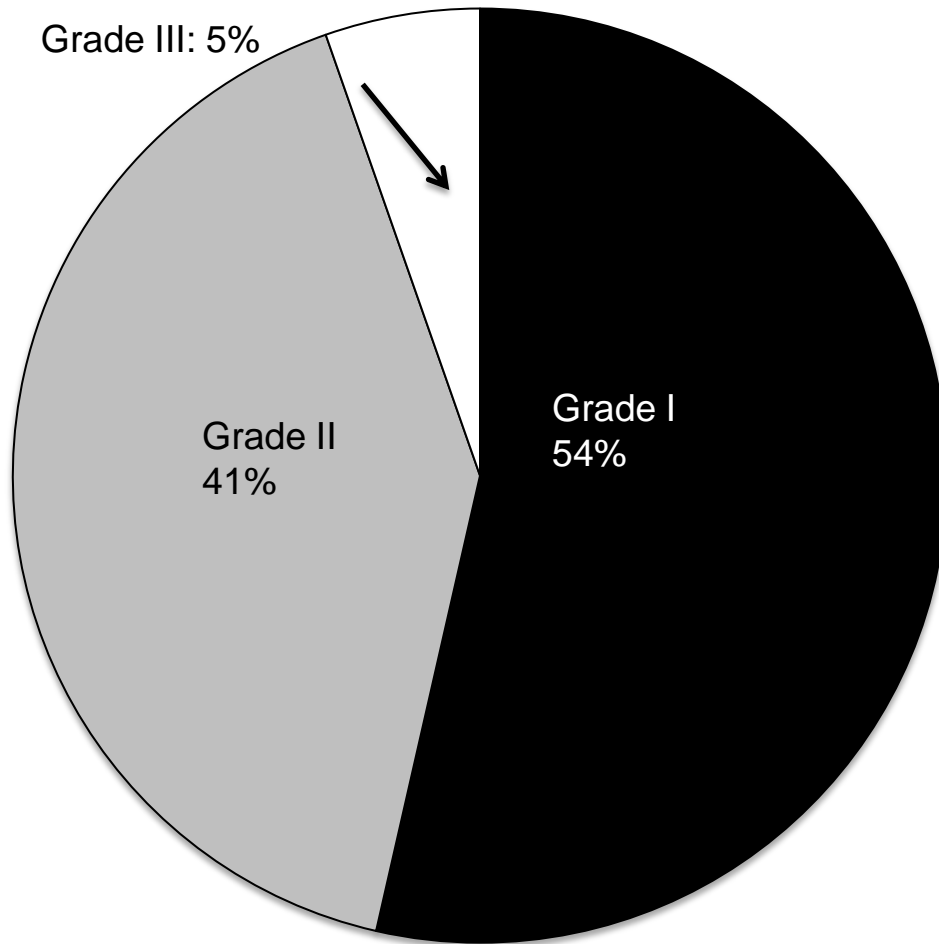
Blast Exposures

| | <10 meters | 11-25 meters | 26-100 meters | Total Blast within 100 meters |
|--|---------------|---------------|----------------|-------------------------------|
| Number of Service Members Exposed | 42 (32%) | 50 (38%) | 91 (69%) | 101 (77%) |
| Mean Blasts/Service Member (SD) | .70 (1.50) | 1.8 (4.74) | 11.5 (47.7) | 14.0 (49.0) |
| Median Number of Blasts/Service Member | 0 | 0 | 1 | 2 |
| Range of Blasts/ Service Member | 0-9 | 0-37 | 0-500 | 0-511 |

Traumatic Brain Injury in OEF/OIF Boston Assessment of TBI-Lifetime (BAT-L)



Military TBI Total



BAT-L

Inter-rater Reliability

Inter-rater reliabilities were strong
(all Kappa's >0.80)

TBI Diagnosis:

OSU* as compared to BAT-L in 131 OEF/OIF Service Members

| OSU | BAT-L (Converted to OSU Scoring) | | | | | |
|-----|----------------------------------|--------|-----------------|--------------------------|-----------------|------------|
| | | 1 | 2 | 3 | 4 | 5 |
| | | no TBI | mTBI Grade I | mTBI Grades II&III | Moderate TBI | Severe TBI |
| | 1 (Improbable TBI) | 42 | 1 | 0 | 0 | 0 |
| | 2 (Possible TBI) | 1 | 32 | 5 | 0 | 0 |
| | 3 (mTBI) | 0 | 0 | 44 | 1 | 0 |
| | 4 (Moderate TBI) | 0 | 0 | 1 | 1 | 0 |
| | 5 (Severe TBI) | 0 | 0 | 0 | 1 | 2 |

Kappa = .89, Kendall's tau-b = .95

*OSU = Ohio State University TBI Identification Method (Corrigan & Bogner, 2007) ¹⁸

Conclusions

The BAT-L is the first validated post-combat semi-structured clinical interview to characterize head injuries and diagnose TBIs throughout the lifespan.

Key considerations in OEF/OIF Veterans

1. Head injuries prior to the military must be assessed
2. Childhood injuries often more severe than military-related injuries
3. TBIs acquired during OEF/OIF are far more likely to be mild in severity rather than moderate to severe
4. Blast exposure was a universal phenomenon (almost 80%)
5. Blast-related TBIs less frequent (20%)
6. If a blast-related TBI did occur -- it was mild

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Download the BAT-L at: <http://heartbrain.com/projects.htm>